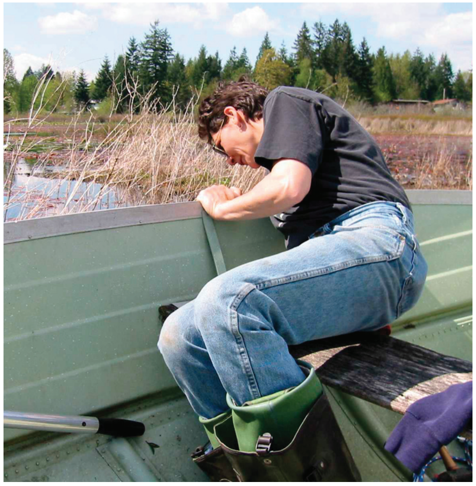
Regional Assessment



Introduction

Regional water quality patterns found in the lakes of the inhabited areas of King County can be produced by comparing the data from all the lakes in water year 2004, as well as examining data for each lake over time and then comparing among the group. Level I monitoring data on precipitation, water levels, and Secchi transparency (water clarity) are compared for all the small lakes measured in 2004. The discussion of Level II monitoring covers the similar comparisons for average phosphorus, nitrogen, the nitrogen to phosphorus ratios, and chlorophyll. Calculations of the Trophic State Indices (TSI) for each lake will also be compared.

SECTION 2A: CLIMATE AND HYDROLOGY

Precipitation

There is a wide range in rainfall received locally through the year because of variation in storm cells, microclimates and land morphology, as well as the patterns of weather movement between the Olympic and the Cascade Ranges (the "convergence zone"). A variety of other factors including rain gauge placement, adherence to protocols, and differences in reading the levels by monitors all influence the precipitation recorded at each location. However, consistently measuring precipitation through the year at each lake makes it possible to look at specific changes in lake level over time relative to the rainfall received in that watershed.

While Level I volunteer monitors collected precipitation data at 37 lakes throughout King County in water year 2004, only 20 lakes had comprehensive rainfall records for the period. If the precipitation records for a lake had some gaps, but had data for at least 330 days, estimated values for the missing days were inserted by averaging all available data from the other lake sites in the county for that day. Discussion of the data set as a whole is limited to the 20 lakes with the most complete data and the area gage at Seattle-Tacoma International Airport.

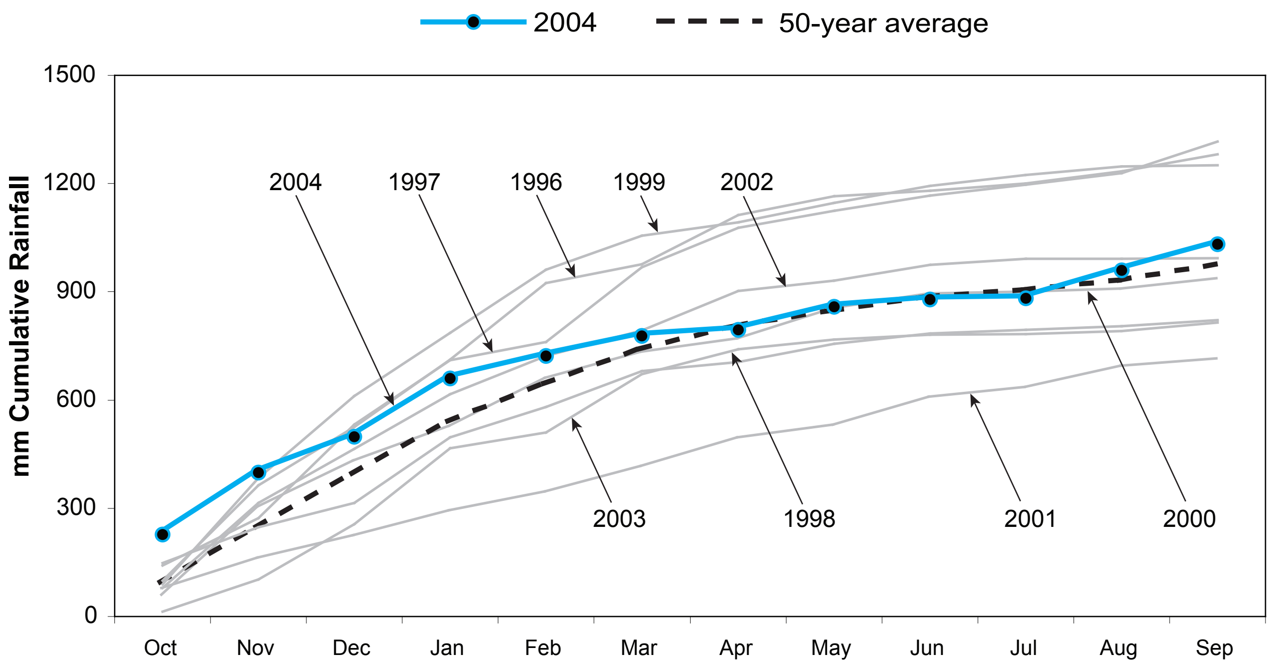


Figure 2-1. Sea-Tac Weather Station: Water Years

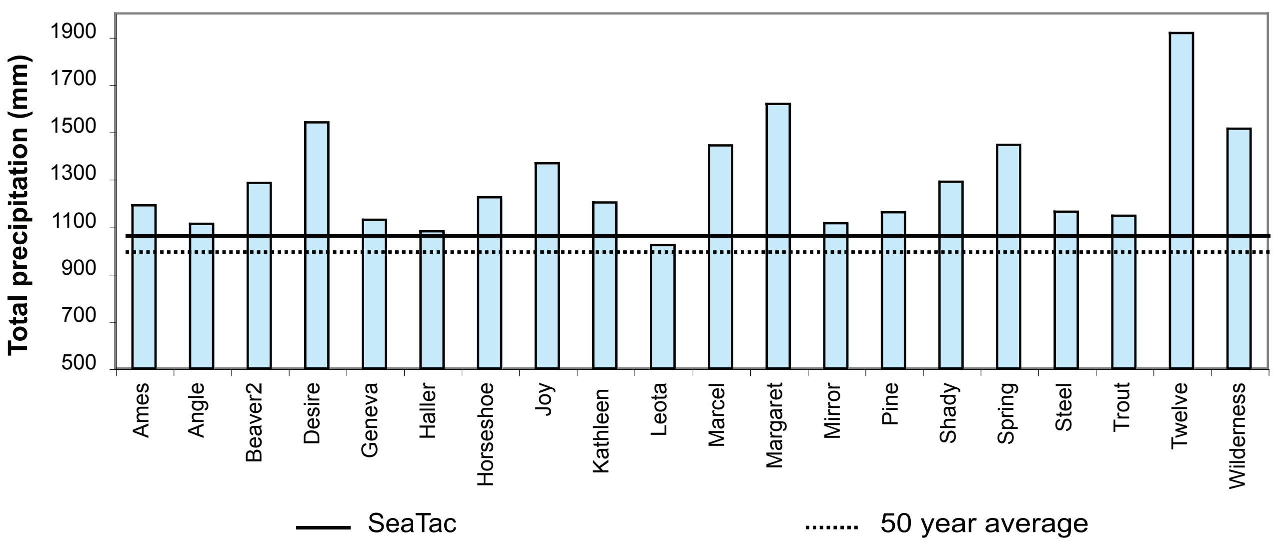


Figure 2-2. Total rainfall at individual lakes for Water Year 2004

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Water Year 2004 Precipitation Data

The sum of accumulated rainfall at Seattle-Tacoma International Airport for the 2004 water year (October 2003 – September 2004) totaled 1032 millimeters (mm), which is well above the 50-year average of 972mm. This can be visualized by comparing it to the last nine years and to the mean accumulation rate for the last 50 years at the Sea-Tac weather station (Figure 2-1). The accumulation rate over the 2003 water year was slightly above the 50-year average through the first six months, was essentially the same as the average the next four, and was again slightly above in the last two months.

Annual precipitation totals for water year 2004 for the 20 lake sites when compared to that for Sea-Tac (Figure 2-2) show that almost all sites recorded greater precipitation than the airport gage site (solid line across chart). The differences between the various sites illustrate the influence that location has on both daily and annual precipitation values. Since many of the small lakes are located in the middle of the county to the east of the airport location or in the south county, this suggests that there is a consistency found in the pattern and that Sea-Tac data should be regarded as a minimum for rainfall in the area.

Lake Level

Fluctuations of water level in lakes are affected both directly and indirectly by area precipitation. Other major influences include:

(1) watershed size (also called the "catchment basin");

(2) land use within the watershed boundaries;

(3) vegetation types and coverage;

(4) nearby or adjacent wetlands;

(5) soil structures and types, as well as the specific geology of the area;

(6) surface and subterranean hydrology;

(7) outlet type or structure, with or without management; and

(8) the volume of water the lake holds relative to the size of the watershed that receives the rain.

These factors combine to give each lake a pattern of water level change that is unique.

Nonetheless, some common fluctuation patterns can be found among lakes. In general, lakes in urbanized watersheds commonly respond to precipitation events more quickly and have greater fluctuations in water level than lakes in undeveloped watersheds. This is largely due to the increase in impervious surfaces, as well as the collection and channelization of surface run-off for quick removal from developed properties. Lakes with large watersheds may have a delayed response to precipitation because of the distance that runoff travels before entering the lake. Lakes with large surface areas or volumes relative to the size of the watershed are often less responsive than other lakes because the water from a storm event is small relative to the volume they already contain.

Sometimes other factors become important in water level changes. Beavers building dams on outlet streams can keep lake levels high through the summer, while human destruction of such dams can cause sudden drops in water level and unexpected surges of water downstream. Readjusting heights of weirs on outlet streams can also account for unusual patterns in lake levels.

Lake Level Fluctuations 2004

Predictable seasonal fluctuations in lake levels were observed at most of the lakes with complete data sets. Water levels were typically at the lowest stand during fall (the end of the water year) and steadily increased during late fall / early winter as precipitation increased (see Section 3 for individual lake results). During the fall and winter, many lakes also showed the greatest fluctuation in daily lake level readings, as storm runoff from watersheds with saturated soils or a high percentage of impervious surfaces quickly flowed to the lakes instead of percolating through soil horizons. This type of runoff pattern caused peaks in water levels to mirror large precipitation events closely, which can be seen in records for individual lakes.

The range in water level is the difference between the maximum and minimum stands over the entire water year. Changes in a particular lake from year to year can be compared as well as comparing records between lakes. Lakes with large fluctuations often show their high sensitivities to winter precipitation and run-off, as well as to evaporative loss through summer. Lakes with small variations in water level probably receive a higher percentage of ground water inputs, which are a steadier source of water through the year than rainfall. Some lakes are managed at the outlet for desired water levels, but this does not necessarily mean that the annual range will be small. For example, Lake Margaret is kept lower in the winter as a buffer against high levels following rainstorms and is allowed to rise to high levels in the spring in order to store water for domestic use by homeowners in the area. Its fluctuation is controlled for the benefit of the community.

Where essentially complete records were available for comparison, lake level ranges in most cases were either approximately the same or higher than for water years 2001 - 2003. Seventeen of the recorded annual ranges for the lakes were the higher in 2004 than records over the last five years (Figure 2-3). Lakes which varied about the same in 2004 or

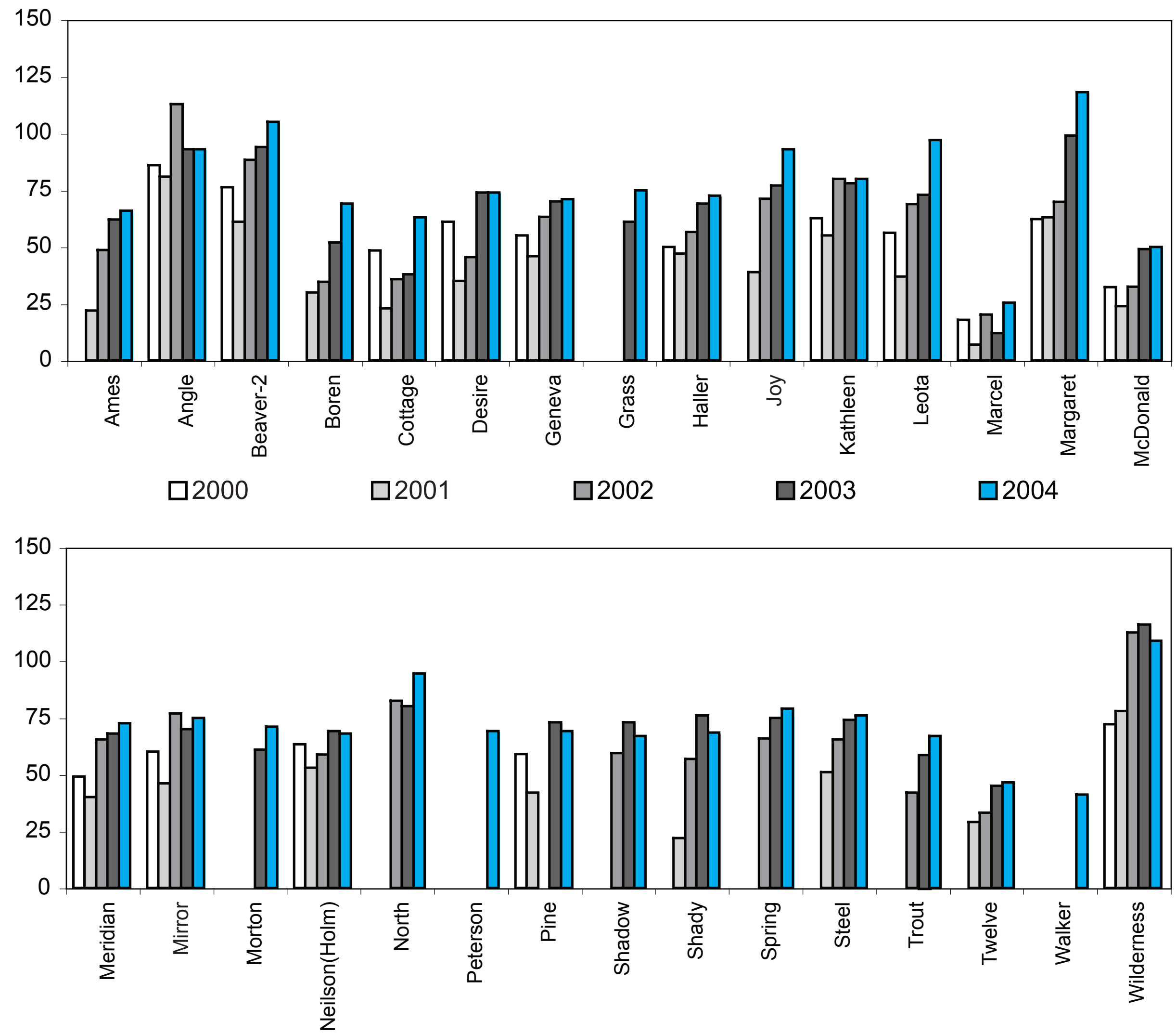

Figure 2-3. Annual Range in Lake Level, 2000-2004

less than in the past included Angle, Desire, Geneva, Kathleen, McDonald, Mirror, Neilson (Holm), Pine, Shadow, Shady, and Wilderness. The lakes with the widest average fluctuation over the last five years (Figure 2-4) included Wilderness, Angle, Beaver-2, and Margaret. Most of the lakes had a more moderate variation, but several showed little average change through the season, including Ames, Boren, Cottage, McDonald, and Marcel. Some the latter named lakes are known to have beaver populations living near outlet streams.

Studying records of annual maximum high water level can indicate whether or not a lake was at its capacity for water storage (at or above the threshold of the outlet) at the at the end of the wet season each year. It may also be an indicator of whether a lake rose to unusual heights at any point during the wet season (Figure 2-5). The reported values for high water levels cannot be compared from lake to lake because the measurements for each lake are relative, based on reading the waterline mark on a fixed meter stick. However, an idea can be gained of whether or not the lake was at capacity by comparing high precipitation years with low ones; for this report the best years to contrast would be 2004 (the last bar) with 2001(the first shaded bar). As an example, Lake Marcel has had a more or less equivalent level for the last five years, suggesting that inputs were balanced by water flowing out rapidly enough to maintain the winter level at a stable height. On the other hand, Lake Boren had a higher stand in 2004 than in the other four years, suggesting that it may have a rapid response to large rainfall events that can lead to a larger fluctuation over the season and from year to year.

Conclusion

Many volunteers recorded higher ranges of lake level fluctuations in 2004 than in the previous 5 years, and this was matched by higher maximum stands. This suggests that many of the higher ranges could have been due to very high winter stands in response to stormwater input rather than summer rates of evaporation. Continued volunteer observation will be important for determining how changes in natural conditions, management activities, or watershed development all affect individual lake levels. Ongoing monitoring will help lakeside residents, citizens in nearby communities, and city and county officials to understand more thoroughly the trends and relationships of water level fluctuations with precipitation, thus leading to more effective drainage management.

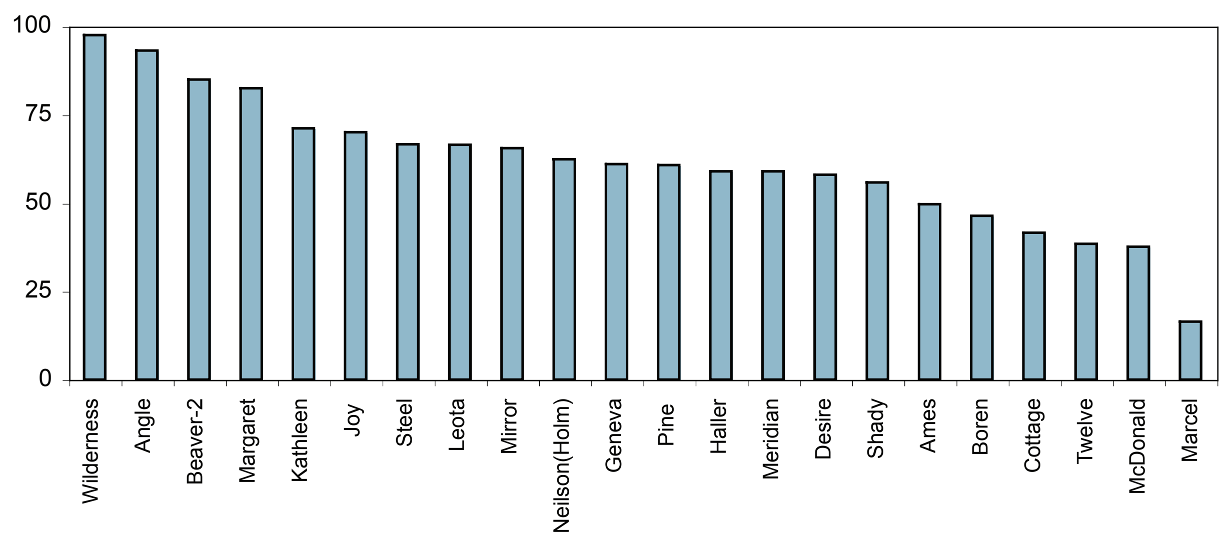

Figure 2-4. Mean Annual Range over the Last Five Years for Lakes with at Least Four Years of Data

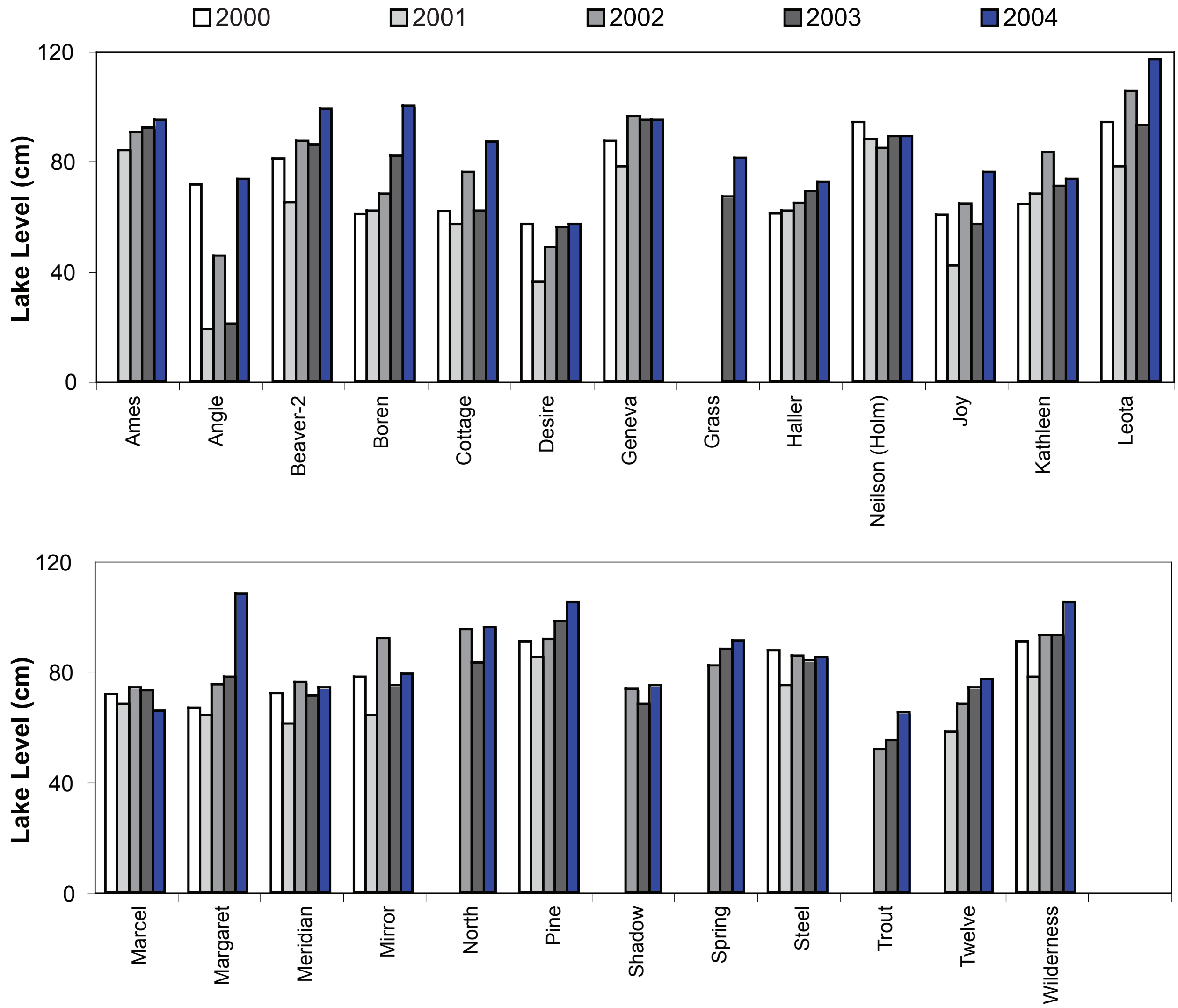

Figure 2-5. Maximum Water Levels, 2000-2004

SECTION 2B: NUTRIENTS

Secchi Transparency

The Secchi depth measures the relative transparency or clarity of the water to an observer above the lake surface. Transparency can be affected by water color (which is affected by concentrations of large organic molecules called “humic acids”), phytoplankton abundance and species make-up of the community, and turbidity caused by other suspended particles. Secchi transparency readings can also be affected by wind and waves, as well as by light glare off the water surface. The sample protocol calls for measurements to be made in the same fashion each time, with records of wind and sun conditions, in order to evaluate the data.

Transparency changes often mirror changes in algal abundance, due either to changes in growth rates from nutrient availability or in grazing rates by zooplankton. It can also indicate major inputs of silt and detritus, such as soils dislodged by large storms or moved into water as a result of human activities. Transparency measurements compared across years may indicate correlations with specific events known to have occurred.

Secchi Depth 2004

Average annual Secchi depths for lakes measured by the Level I volunteers over the last five years can be grouped by the Trophic State Indicator (TSI) value, which is based on the depth measurements (Figure 2.6). A Secchi reading of 2 meters depth equates to a TSI value of 50, which is on the threshold between mesotrophic and eutrophic productivity, while a Secchi reading of 4 m equates to a TSI of 40, which marks the change from oligotrophic to mesotrophic productivity. The dotted lines in Figure 2-7 mark these thresholds.

The annual mean Secchi values for the lakes with complete records over the past five years show a range of values over time. Lakes with clarity usually deeper than 4 m include Ames, Angle, Margaret, Pine, and Wilderness. However, Margaret had been decreasing in clarity between 2000-2003, but was clearer again in 2004. Meridian was well above 4 m in 2000-2002, but dropped below in 2003 and went even lower in 2004. In contrast, Mirror Lake was less than 4 m in 2000-2001, but increased in clarity in 2003-2004. Most of the lakes were between 2 to 4m in average clarity, and there were few large fluctuations from year to year among them. Kathleen appears to be increasing in clarity over the years, as does Marcel. Two lakes, Cottage and Desire, remained below the 2m threshold for all the years depicted.

In some cases, lower Secchi depths may be caused by particle inputs from storm water runoff. To evaluate this possibility, Level I Secchi depths for 2004 were divided into two time periods (Figure 2-7) to see if the influence of storm water runoff (November-February) could be separated from influences associated with summer algal blooms (July-August). Spring and autumn data were not included in this analysis because both major storm events and large phytoplankton blooms can occur during those seasons, thus confusing the interpretation.

During the wet months, significantly smaller transparencies were observed for 11 of the 24 lakes in the program with comprehensive annual data for Secchi depth, indicating that storm water runoff probably influenced water clarity in these lakes to a greater degree than the summer algal populations. In addition to storm water inputs, wave action (due to strong winds) and low light levels during the winter months can be an important factor influencing lower average Secchi depth measurements. Eight of the lakes had significantly lower transparencies in the summer, indicating algal blooms may have impacted water clarity. These included Ames, Beaver-2, Haller, Joy, Mirror, Neilson (Holm), and Twelve. Four lakes were essentially the same transparency in both seasons, including Angle, Geneva, Margaret, and Wilderness.

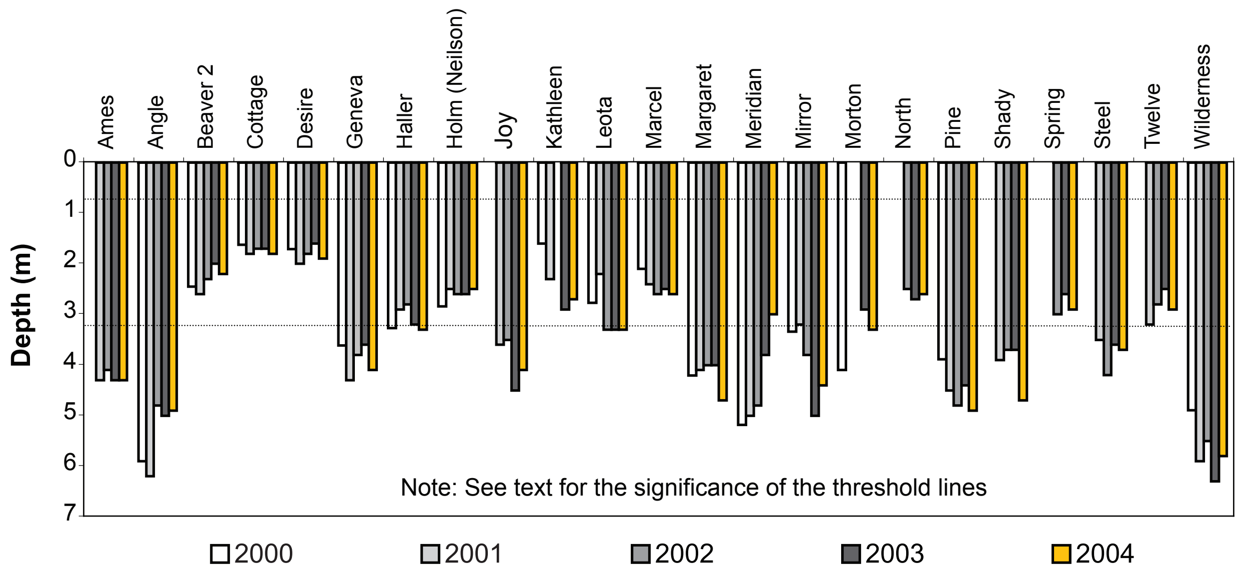

Figure 2-6. Average Annual Secchi Transparency, 2000-2004

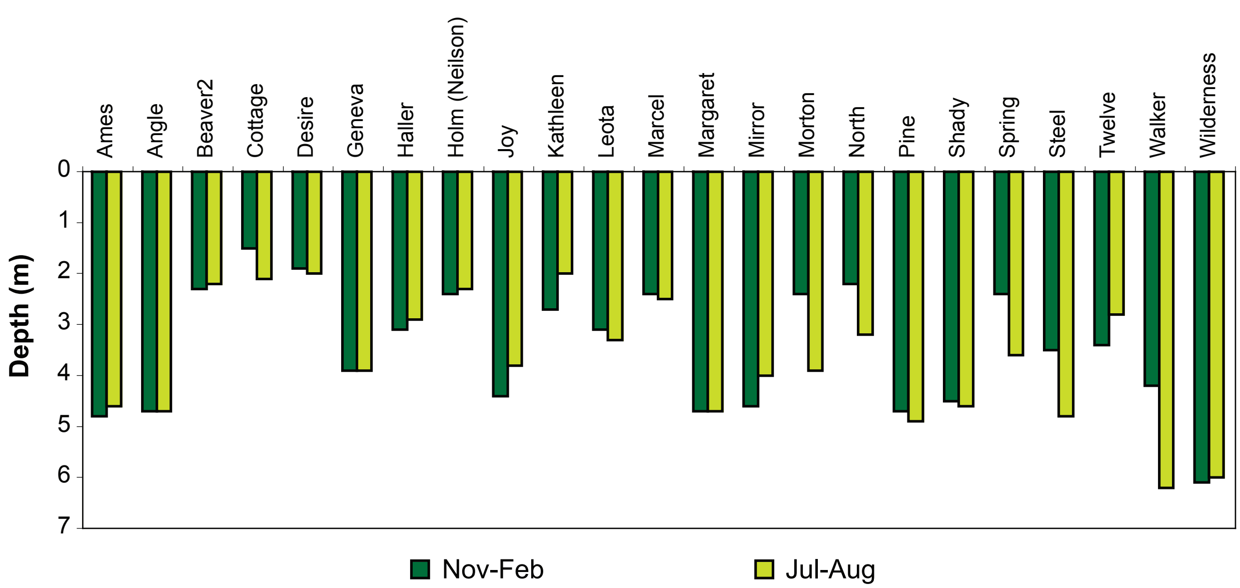

Figure 2-7. Wet/Dry Season Secchi Comparisons

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Total Phosphorus

Many water quality problems in lakes can be related to high concentrations of nutrients that stimulate the growth of algae and aquatic plants. In temperate freshwater systems, the nutrient that limits algae growth is most often phosphorus, although phytoplankton can be occasionally limited by nitrogen concentrations or even by silica or iron. Before trying to manage a water quality problem, it is important to know which nutrient is limiting plant growth most frequently in the lake.

Since phosphorus is generally considered to be the nutrient in shortest supply in this geographic region for algae growing in lake water, keeping track of the concentrations during the growing season is considered essential to a basic water quality monitoring program.

Many lakes have similar mean phosphorus levels from year to year, although some variation can be expected to occur. Seven concurrent years of phosphorus averages were examined for the lakes monitored in 2004 (Figure 2-8). Three-year running averages were calculated in order to smooth out year-to-year variability. In addition, the increases and decreases between successive years were tallied to look for overall directions of change.

Thirty-one of the 43 lakes with multiple years of data yielded average total phosphorus concentrations over past years without any marked trend of increase or decrease. Several lakes had large swings in phosphorus between years, including Allen, Grass, Leota, Marcel, Paradise, and Trout. Six lakes with total phosphorus that decreased steadily included Beaver-1, Francis, McDonald, Mirror, and Welcome. Lakes with steadily increasing phosphorus concentrations included Angle, Echo (in Shoreline), Horseshoe, and Kathleen. Lakes that showed a potential of increasing over time included Alice, Boren and Spring.

Clark, Echo (in Snoqualmie), Peterson Pond, Walker, and Yellow Lakes reported Level II data for the first or second time, and these lakes will need more years of data collection before patterns begin to emerge.

Total Nitrogen

Nitrogen is usually about ten times more abundant in the environment than phosphorus, but can become limiting on occasion when phosphorus concentrations have increased. The ratio of nitrogen to phosphorus can determine which algal species are present in a body of water because of their differing needs.

The same types of analyses were performed on nitrogen concentrations in the monitored lakes as were done for phosphorus (Figure 2-9). Thirty-two of the 43 lakes with multiple years of data yielded average total nitrogen concentrations over past years without any marked trend of increase or decrease. Several lakes had large swings in nitrogen between years, including Allen, Cottage, Desire, Horseshoe, and Jones. Welcome Lake had total nitrogen that decreased steadily while lakes that could be decreasing included Leota and McDonald. Lakes with steadily increasing nitrogen concentrations included Alice, Angle, Kathleen, and Shadow. Lakes that showed a possibility of increase over time included Boren, Fenwick, Fivemile, and Neilson (Holm).

Clark, Echo (in Snoqualmie), Peterson Pond, Walker, and Yellow Lakes reported Level II data for the first or second time, and these lakes will need more years of data collection before patterns begin to emerge.

Nitrogen: Phosphorus Ratios

One way to make a quick nutrient assessment of a lake is to calculate nitrogen to phosphorus ratios (N:P). Generally, nitrogen to phosphorus ratios of 17:1 or greater suggest that phosphorus is the nutrient for algae that is the least available (Carroll and Pelletier 1991). Within each lake, the ratio varies throughout the growing season. Some lakes are primarily phosphorus limited, but occasionally may be nitrogen limited. Others are solely governed by one nutrient which is in the shortest

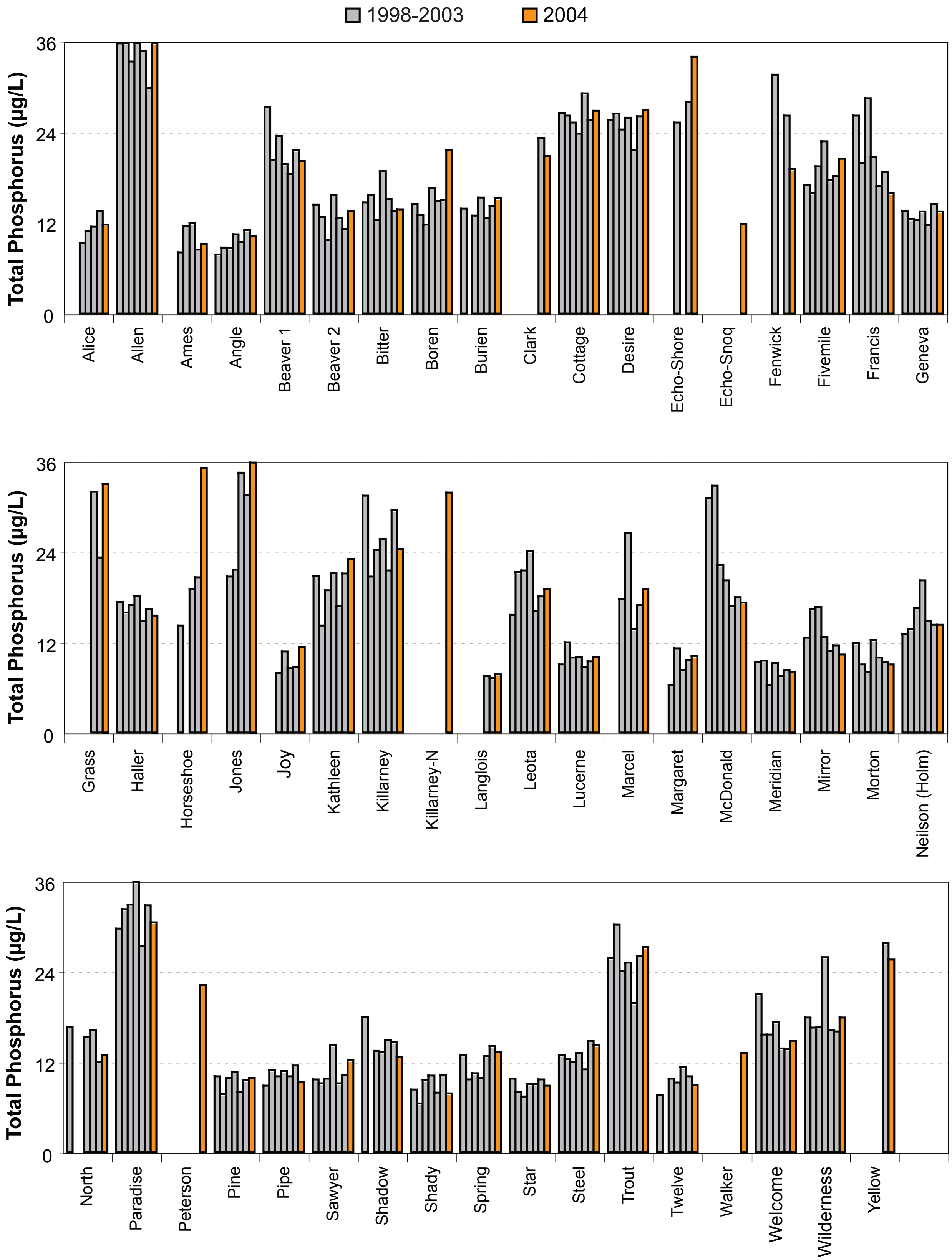

Figure 2-8. Average Total Phosphorus, May-October, 1998-2004

Regional Assessment

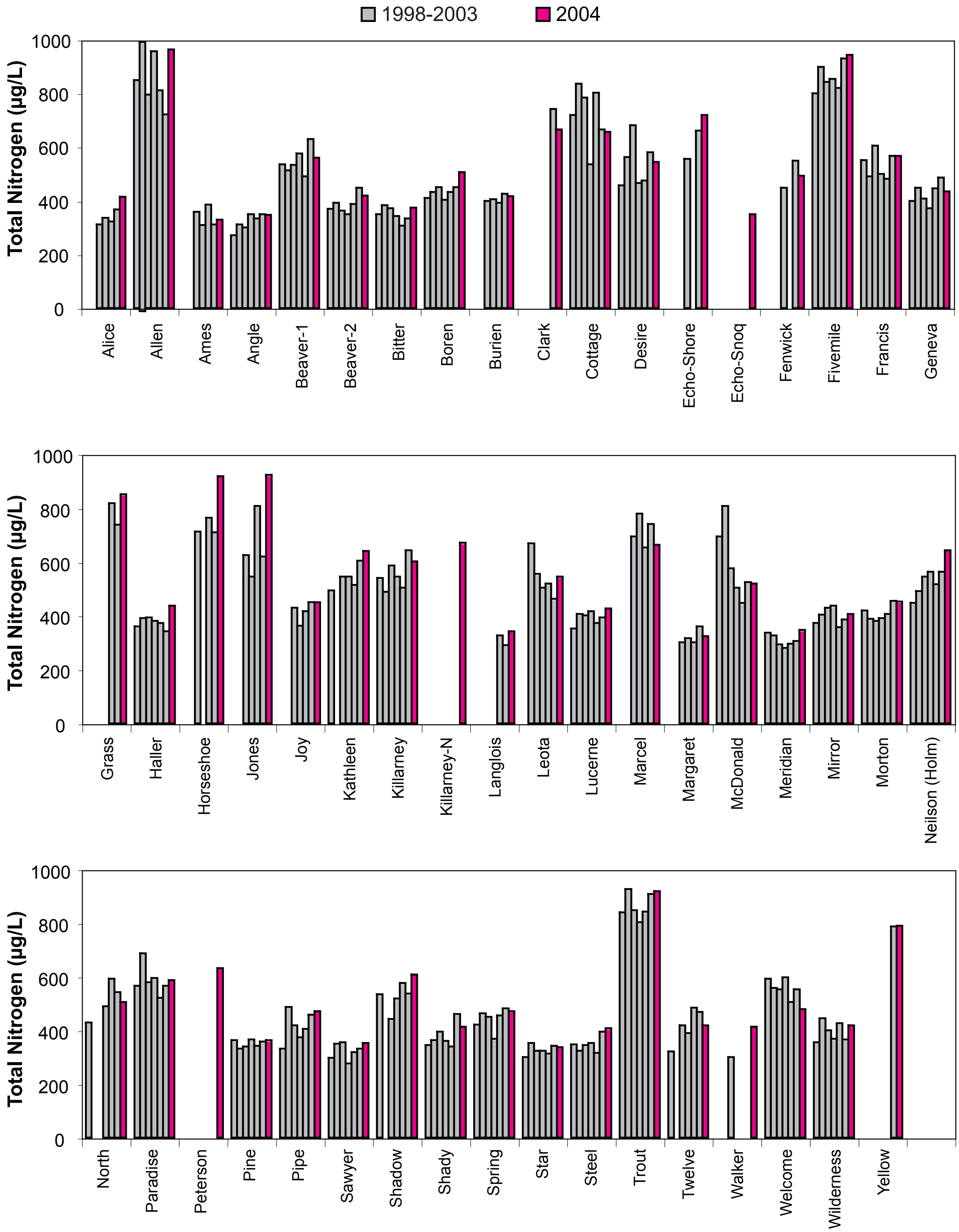

Figure 2-9. Average Total Nitrogen, May-October, 1998-2004

supply through the season. Lower nitrogen to phosphorus ratios can favor bluegreens over other algal species, because some bluegreen species are able to use nitrogen from the air, unlike other algae. A ratio of 20:1 or below is generally indicative of potentially advantageous conditions for bluegreen growth.

A biological wrinkle in using N:P ratios to assess the potential for algal growth is that some algae can take up phosphorus and store it for use later in the season when phosphorus concentrations have become very low in the epilimnion (so-called “luxury uptake”). Thus, the population growth rates of such algae may be reflecting earlier conditions of phosphorus availability rather than the period during which they are being measured.

2004 Ratios

Only one lake, Paradise, had an average N:P ratio close to 20 for the period of May-October 2003 (Figure 2-10), although individual sample dates producing ratios below 20 have been common in certain lakes over the past ten years. Upward trends through time in average N:P ratios can be seen for 7 of the lakes, including Francis, McDonald, Meridian, Mirror, Morton, Shadow and Trout, which could signal a change in the future away from bluegreen populations. Consistent declines were seen in only Horseshoe and Jones Lakes, both of which have relatively short records. The average ratios in other lakes either changed greatly from year to year or showed no particular trend or directionality.

Some lakes had average ratios well above 20, but experienced distinct periods during the sample season with ratio values at or below the threshold. Several lakes had higher N:P ratios in spring, which either dropped steadily through the summer or declined more abruptly in early fall to levels at or below the 20 threshold. Lakes in this group included Cottage, Desire, Echo (in Snoqualmie), Fenwick, Haller, Horseshoe, Leota, Sawyer, and Wilderness. Lakes Beaver-1 and Echo (in Shoreline) had the opposite pattern of starting low and then rising to a higher level the rest of the season. Two lakes, Boren and Killarney, started high, dropped in mid summer, and then rose again. Any of these periods of low N:P ratios could have encouraged growth by nuisance bluegreen species.

Conclusions

For the majority of lakes in King County, average May – October phosphorus concentrations have either remained steady or have varies without trend in recent years, including 2004. Seven lakes in the monitoring program have shown steady gains recently, and only two appear to be steadily declining. Average N:P ratios suggest that conditions for bluegreen algae are becoming less favorable overall, thus reducing the possibility of toxic bluegreen blooms on a region-wide basis, although some lakes may still be at risk, particularly during specific periods.

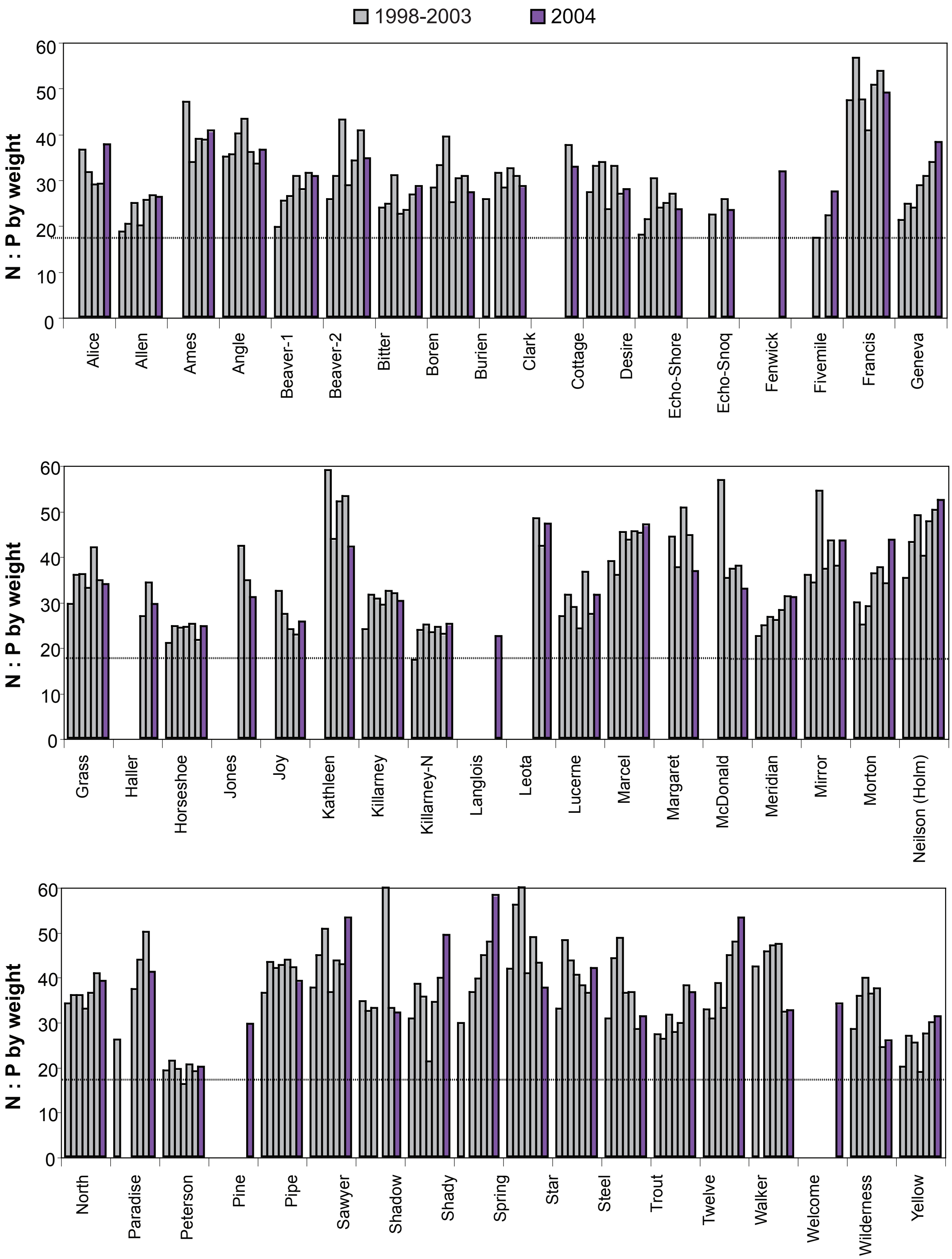

Figure 2-10. Nitrogen To Phosphorus Ratio, May - October, 1998-2004

SECTION 2C: CHLOROPHYLL AND TROPHIC STATE INDEX

Chlorophyll *a*

Variability is often much greater from year to year in chlorophyll *a* concentrations than it is for nutrients or the N:P ratio. This is not surprising, since many different factors can influence algae concentrations at the time a water sample is taken. For example, the phytoplankton populations in a lake can be concentrated into an area by wind and water movements and so may not be evenly distributed at the time of sampling. Lack of wind can cause bluegreens to float up to the surface, concentrating them at the top of the water column, while other species, such as chlorophytes and diatoms, may sink down towards the thermocline, out of the surface water.

In addition, algal species present in a lake can change from year to year, and algal species differ in the amount of chlorophyll per cell, so estimates of populations. For example, large blooms of bluegreens (cyanobacteria) may yield less chlorophyll than equivalent volumes of green algae (chlorophytes) because many bluegreens have accessory pigments in addition to the chlorophyll that are used to capture light for photosynthesis. The amount of chlorophyll *a* per cell can also vary with the health and age of the population as well.

Even with all the variables that come into play on each sampling date, the annual May-October averages of chlorophyll (Figure 2-11) demonstrate that most of the lakes in the program have generally similar average concentrations from year to year or else vary within a definable range. This is particularly true of lakes in the lower end of average concentrations, including: Alice, Ames, Angle, Burien, Echo (in Snoqualmie), Joy, Langlois, Lucerne, Meridian, Pine, Pipe, Star, and Walker. For this chart, the lakes are arranged by ascending average chlorophyll values for all the available data from each lake.

The dashed lines on the chart mark the thresholds for Trophic State Indicators. The lower line marks the transition between oligotrophic and mesotrophic, while the upper dashed line marks the change from mesotrophic to eutrophic. While lakes with lower overall chlorophyll averages tend not to vary a great deal, some lakes in the middle of the distribution may have one or two years in which chlorophyll was significantly higher than in the other years. Lakes with this pattern include North, Spring, Beaver-2, Twelve, Jones, Killarney, Mirror, and Beaver-1. Such high averages may be anomalous and not repeated in the future, or could also be indications of regularly occurring, but ephemeral, blooms that coincided with a sampling date in a particular year, but may be missed in others because of the two-week gap between sample collections.

Average annual chlorophyll values for lakes with high concentrations often varied a great deal from year to year, but were generally considerably higher than other lakes in the program. These lakes included Allen, Cottage, Desire, Francis, Grass, Kathleen, Killarney, Paradise, Trout, and Welcome. Marcel has decreased sharply since the first years of monitoring. McDonald also has decreased steadily from 1998 to 2001, but has remained steady since then. Welcome may also have decreased with a sharp decline in 2002 that has persisted in 2003-2004. Leota appeared to be increasing over time, but dropped in 2002-2003 and climbed in 2004.

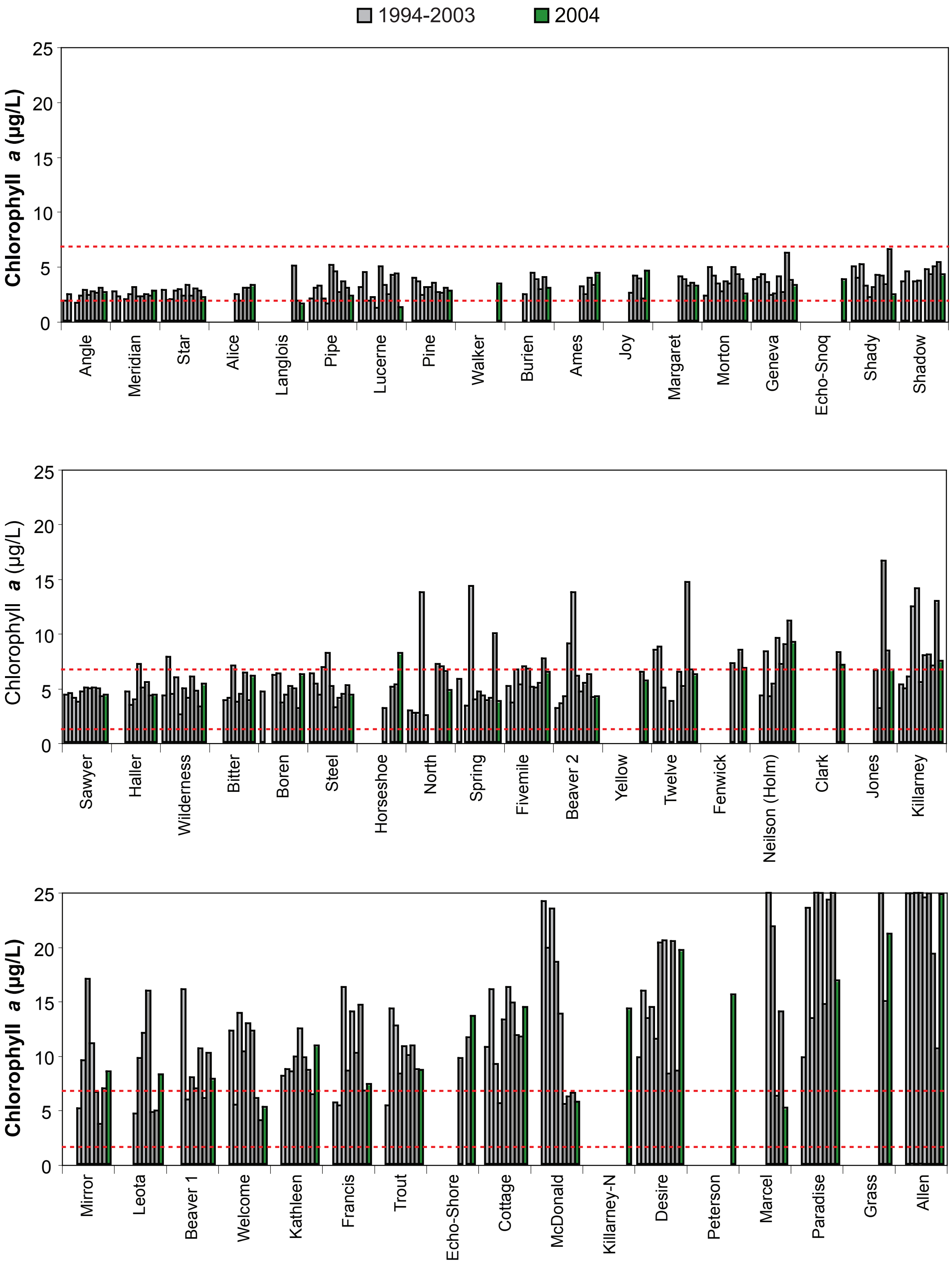

Figure 2-11. Average Chlorophyll-*a*, May - October, 1994-2004

Conclusion

Average concentrations of chlorophyll *a* may vary a great deal from year to year, particularly in lakes with large amounts of algae. Concentration of algae by wind and water movements can lead to samples that are not representative of the lake as a whole, being either too high or too low. However, chlorophyll concentrations are rarely high at lakes with low over-all productivity and the yearly averages generally appear to be within a constant range. Chlorophyll tends to vary more at lakes with high phytoplankton abundances, such as at Allen. As a measure of productivity, chlorophyll may be subject to more variability than either Secchi or TP.

Most lakes within the volunteer monitoring program either remained steady in 2004 relative to other years or continued a pattern of unpredictable variability from year to year. Lakes which may be showing downward trends over recent years include Pine, Trout, McDonald, Welcome and Marcel. Lakes which may be showing upward trends, although some are small in magnitude, include Angle, Meridian, Alice, Neilson (Holm), and Paradise.

Trophic State Index

The productivity of lakes can be classified using calculated values that predict biological activity called the Trophic State Index (TSI), based on conditions in the lake. TSI values provide a standard measure to rate lakes on a scale of 0 to 100. Each major division (10, 20, 30, etc.) correlates a doubling of algal biovolume to various measurable parameters by linear regression and re-scaling (Carlson, 1977). The indices are based on the summer mean values (May through October) of three commonly measured lake parameters: Secchi depth, total phosphorus, and chlorophyll *a*.

The relationships are not always straightforward. Carlson points out that highly colored lakes containing large amount of dissolved organic matter may produce erroneously high TSI ratings for Secchi transparency, since the clarity is impacted by water color. The shape and size of phytoplankton species can also influence the Secchi reading, as well as the chlorophyll values, since small, diffuse algae cloud the water more than large, dense algal colonies and species of algae vary in the amount of chlorophyll they contain.

It is important to note that the total phosphorus measure is most reliable for lakes that are strictly phosphorus limited for algal nutrition, and the TSI relationships often fall apart when nitrogen is the limiting nutrient instead. Although no lakes in King County have been identified as solely governed by nitrogen limitation, there are several lakes in which nitrogen appears to be limiting at times through the season or in which phosphorus and nitrogen limitations occasionally alternate or operate together.

2004 TSI Ratings

TSI values were calculated for the three parameters measured on each sampling date for the 51 lakes monitored by Level II volunteers (Figure 2-12), and the average for each was produced for the season. The lakes were arranged by the average of all three TSI values in descending order to show the range of values found for monitored lakes in the county. TSI values calculated over the past nine years for each lake are included in the individual lake descriptions (see Section 3).

Carlson (1977) points out that if all the assumptions are correct, the TSI values produced for the three different parameters should be very close to each other. Many King County lakes follow this prediction, but several have values that are not very close, suggesting that some different conditions or processes are active at those lakes. When lakes have two close TSI values and one very different one, the outlying value could be excluded from consideration if a reasonable hypothesis is put forward to explain the differing value.

Regional Assessment

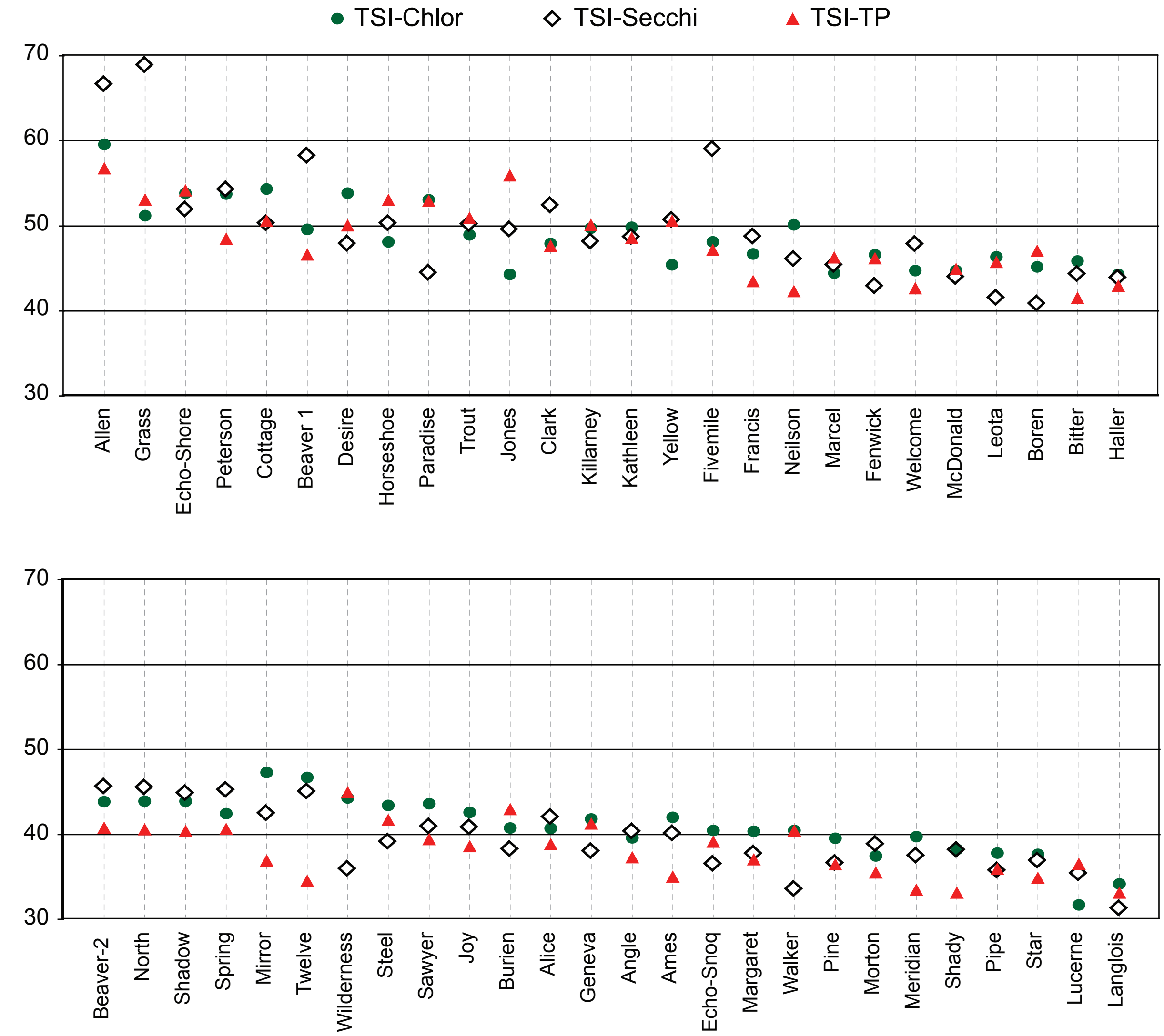

Figure 2-12. TSI Values for all Lakes in 2004

There are four King County lakes in 2004 whose trophic assignment could be reassessed, based on the difference between the TSI-Secchi and the other values: Allen, Grass, Beaver-1, and Fivemile. All are relatively easy to evaluate because the TSI-TP and TSI-chlor are closer together, while the TSI-Secchi is much higher. All four lakes have tea-colored water (King County, 2002), which impacts the TSI-Secchi values causing higher predictions of lake productivity than may actually exist. Without the TSI-Secchi value included, Fivemile productivity is assessed as mesotrophic rather than eutrophic, while Beaver-1 is at the threshold between the two classifications. All three TSI values for both Allen and Grass are above the threshold for eutrophy.

Several lakes had TSI-Secchi values lower than the other three indicators, suggesting unexpected clarity. This can happen when the dominant algal species make large colonies that appear in the water as particles rather than creating cloudiness. Lakes which showed this pattern included Paradise, Wilderness, Leota, and Boren.

Several lakes had significantly lower TSI-TP than the other two parameters. These included Peterson Pond, Twelve, Ames and Shady. This may also be related to the configuration of the algae, but could also have to do with KC Environmental Labs analytical protocols, which may have introduced a systematic bias for certain lakes with particular types of phosphorus compounds. This matter is currently under investigation, and some past values may be corrected.

Oligotrophic lakes with TSI values less than 40 are considered to have low biological activity, with high clarity and low concentrations of chlorophyll *a* and total phosphorus. Nine lakes met this criterion for all three calculations of TSI at or below the threshold: Langlois, Lucerne, Star, pipe, Shady, Meridian, Morton, Pine, and Walker. Three other lakes had two out of three TSI values below 40: Margaret, Echo-Snoqualmie, and Angle.

Mesotrophic lakes have TSI ratings between 40 and 50. They are considered to be transitional between being relatively nonproductive and very productive biologically. In 2004, with two out of three indicators above the threshold or all three very near the threshold, seven transitional lakes included Ames, Geneva, Burien, Joy, Sawyer, and Steel.

Lakes slightly more productive, but considered in the lower range of mesotrophy included Wilderness, Twelve, Mirror, and Spring. The middle range mesotrophic lakes, with all three indicators in or near the middle of the 40-50 range included Shadow, North, Beaver-2, Haller, Bitter, Boren, Leota, McDonald, Welcome, Fenwick, and Marcel.

Higher range mesotrophic lakes, with all TSI values in or near the upper limit of mesotrophy, or with one just over the threshold, included Neilson (Holm), Francis, Kathleen, Killarney, Clark, and Trout. Fivemile is a special case and should be considered as part of this group as well.

Lakes that have TSI values greater than 50 are considered eutrophic, characterized by high biological productivity. Lakes with TSI values that suggested they were on the threshold of eutrophic conditions include Yellow, Jones, Paradise, Horseshoe, Desire, and Beaver-1. Lakes more solidly in the eutrophic classification included Cottage, Peterson Pond, Echo-Shoreline, Grass and Allen.

Conclusion

Although the suite of lakes is not precisely the same from year to year, the years can be compared in a general way to look for geographic trends. As in recent years, the majority of the lakes monitored in King County fall into the mesotrophic range for algal productivity (Figure 2-13). The overall distribution of lakes in 2004 into productivity categories based on TSI values appeared to be about the same as in 2003. In 2000-2001 there were more lakes in the eutrophic categories and fewer in the mesotrophic-eutrophic transition, suggesting that in general productivity may be decreasing over the broad area. In addition, the sum of the lakes in the oligotrophic and oligotrophic-mesotrophic zone have remained about the same.

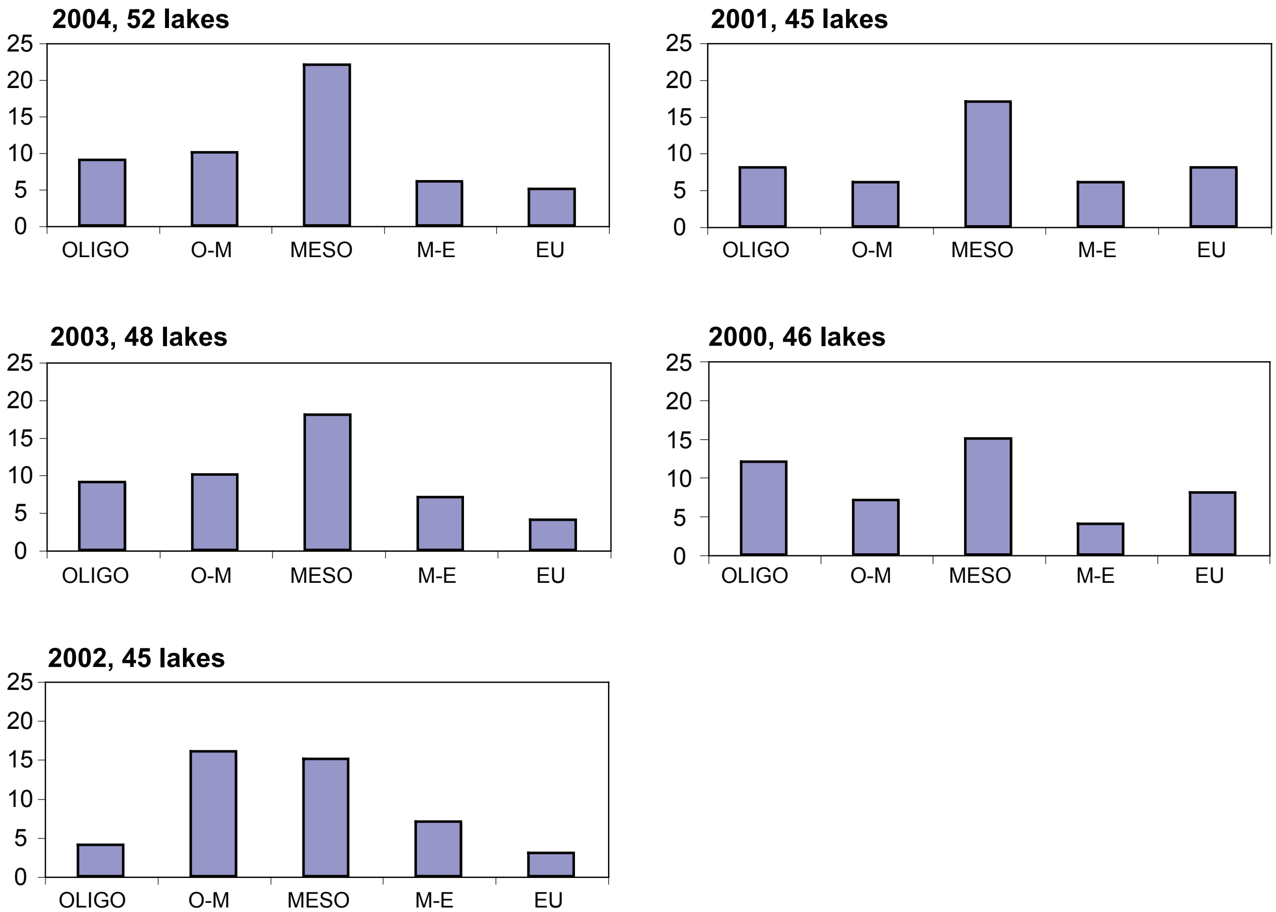

Figure 2-13. Comparison of TSI Lake Classifications 2000-2004